Use of Dilute Flowable Backfill for Corrosion Mitigation of Buried Pipe

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Outline

- **Background**
  - Motivation
  - Dilute Flowable Backfill
- **Experimentation**
  - Field testing at Ft. Hood, TX
  - Laboratory testing at ERDC-CERL
- **Conclusions**

Project Objective

Alkaline cementitious material is used as “flowable backfill” to create an stable, non-corosive environment for buried, ferrous-based metallic piping.

The focus of the evaluation will be to track the performance of the dilute flowable backfill as the cathodic protection is reduced and ultimately disabled

Motivation for Dilute Flowable Backfill

- Ferrous-based metallic piping
  - sewer/industrial waste lines, potable water distribution lines, heat distribution piping
  - exterior plumbing total maintenance cost $572M, with total corrosion cost of $190M

- Preventable corrosive degradation causes a significant proportion ongoing installation expenses
  - Cathodic protection is widely used

- Soil parameters affect severity and extent of corrosion

Dilute Flowable Backfill Properties

Controlled Low Strength Material (CLSM)

- Flowable Fill
  - pulverized aggregate, Portland cement, water
- Soil-Cement
  - natural soil, Portland cement, water

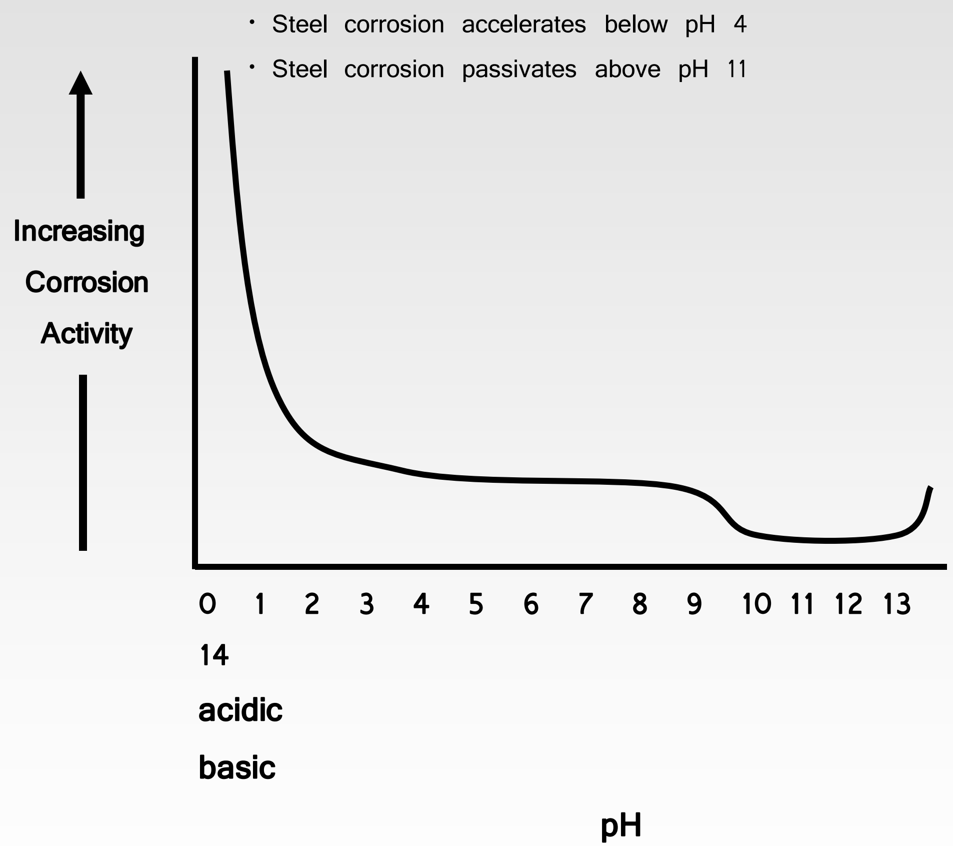
Properties / Differences to Concrete

- Higher air contents to enhance flowability
- Low aggregate to cement ratio
- Low compressive/tensile strengths (easily excavated)
- Low cost

Dilute Flowable Backfill

Corrosion Mitigation Characteristics

- Corrosion protection comes from
  - passivated, adherent oxide film forming on the metal surface
  - alkaline and hydroxyl ions in pore solution elevating material pH
- Bare ferrous metal embedded in flowable backfill is passivated by the high-pH of cement, thus significantly decreasing the corrosion rate
- Represents a potentially simple, inexpensive, and effective method of long-term corrosion protection of buried ferrous pipe



Courtesy of Bushman & Associates, Inc.

Test and Evaluation

- Field Analysis at Fort Hood, TX
  - Evaluate separate steel pipes with corrosion monitoring instrumentation embedded in flowable fill and native soil cement mixtures
- Laboratory Analysis at ERDC-CERL
  - To provide comparative performance results
  - Evaluate several characteristic soils from around the U.S. for the soil-cement corrosion mitigation properties
- Goal is development of criteria for successful usage of soil-cement for corrosion-mitigation pertinent to US Army facilities

Field Analysis

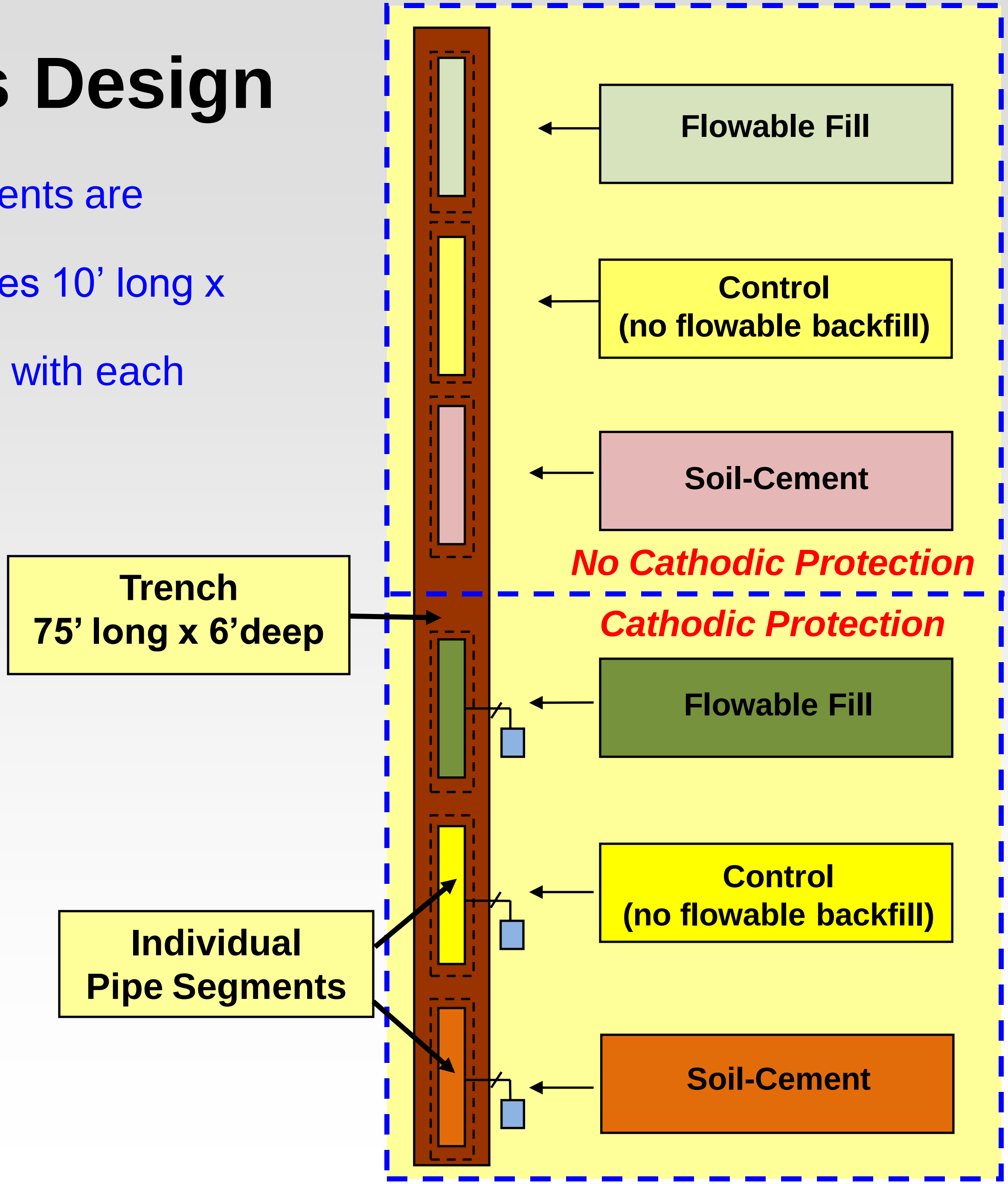
Awarded contract to Mandaree Enterprise Corporation in Sept. 2009 to perform field analysis

Contract Requirements:

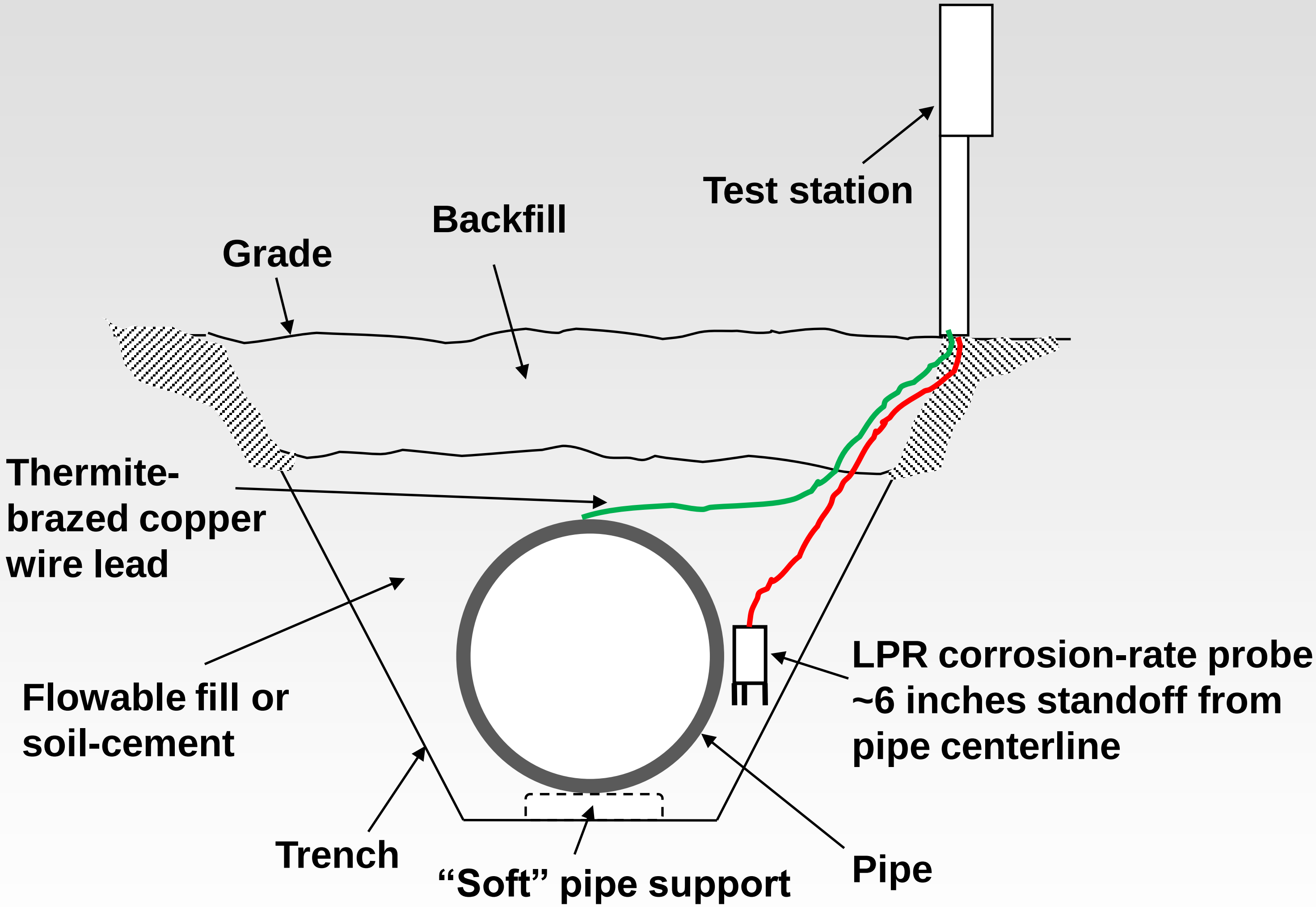
- Steel pipe segments to be embedded in a flowable fill and a soil-cement at Ft. Hood, TX
- Periodic Linear Polarization Resistance (LPR) measurements for corrosion rate monitoring
  - Daily for first week, monthly thereafter for 12 months
- Mass loss measurements on the LPR probe electrodes

Field Analysis Design

- Individual steel pipe segments are buried in a trench 6’ deep
  - Each segment measures 10’ long x 6” in diameter
  - Backfill conditions vary with each segment
- Each set contains 3 samples
  - Control
  - Flowable Fill
  - Soil-Cement
- One set is <u>without</u> Cathodic Protection
- One set is <u>with</u> Cathodic Protection



Field Analysis Schematic



Flowable Backfill Design Specifications

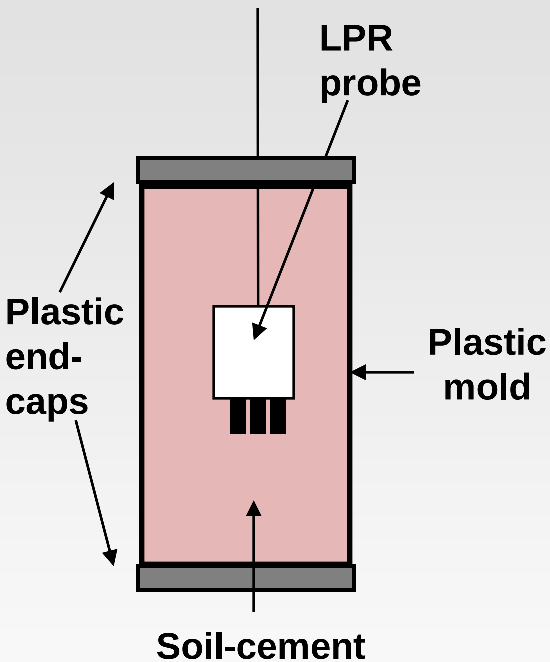
Mix Composition (lb/yd^3)					
Batch Type	**Aggregate**	**Native Soil**	**Cement**	**Water**	**Air**
Flowable Fill	3000	--------	100	600	20%
Soil-Cement	--------	3000	100	600	20%

Unit Weight	140-145 lb/ft^3
Max Slump	9 in
28-Day Compressive Strength	50 – 100 psi

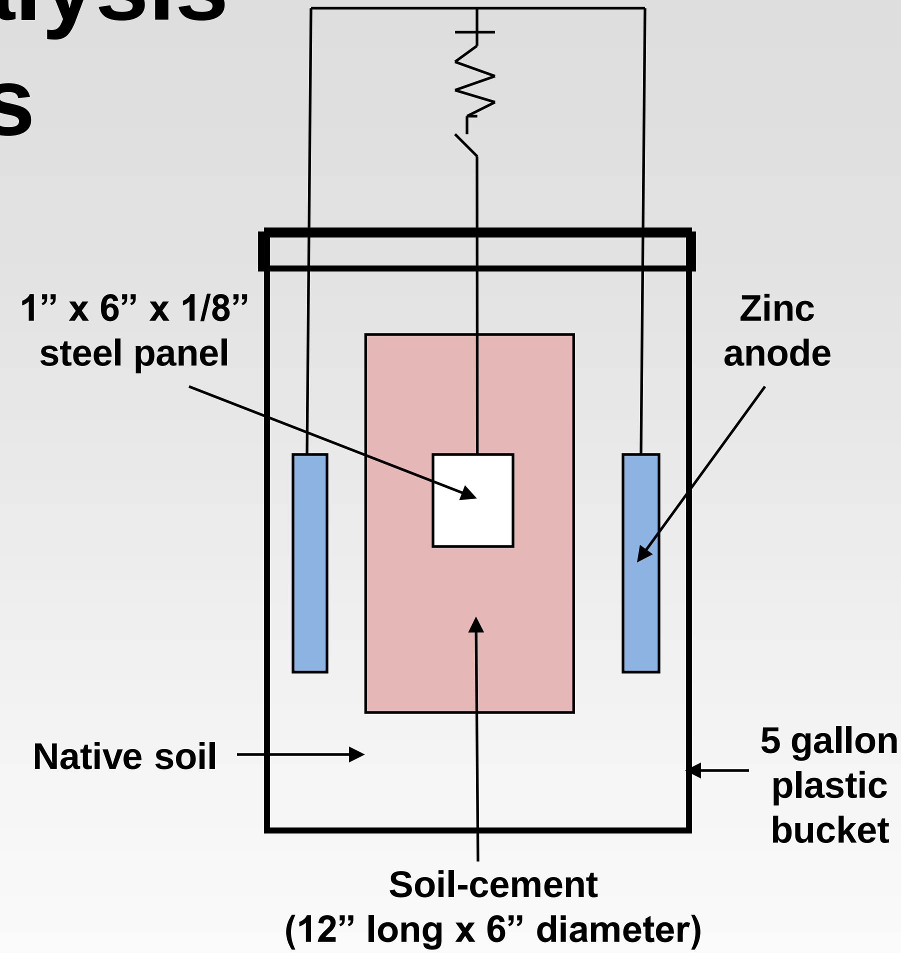
Laboratory Analysis

- To take place at ERDC-CERL concurrently with the Field Analysis
- PVC pipe molds (12” long x 6” in diameter) used to hold steel samples and corrosion measurement equipment
- Molds will be backfilled with soil-cement mixtures from various soils around the U.S.
- Will perform periodic LPR measurements for corrosion rate monitoring
  - Daily for first week, monthly thereafter
- Mass loss measurements on the LPR probe electrodes

Laboratory Analysis Schematics



Soil-cement cylindrical mold



Soil-Cement test arrangement for cathodic protection

Soil Collections

Soil	Description	Location
Sandy	< 20% silt or clay	Desert (Reno, NV)
Coarse sand	>35% fine gravel and coarse sand, < 50% other grades of sand	South East (Savannah, GA)
Sandy Loam	20 – 50% silt and clay	East (Norfolk, VA)
Sandy loam (saline)	20 – 50% silt and clay	West (Fresno, CA)
Loam	<20% clay, 30 – 50% silt, 30 – 50% sand	North East (Hagerstown, PA)
Silt loam	<20% clay, > 50% silt, <30% other classes	Midwest (Memphis, TN)
Clay loam	>30% clay, <70% other classes	South (Houston, TX)

Conclusions

- Dilute flowable backfill (flowable fill or soil-cement mixtures) will be used to entirely encase buried, ferrous-based metallic piping
- Field Analysis will take place at Ft. Hood, TX with 10' sections of steel pipe tested with flowable backfill
- Laboratory Analysis will take place at ERDC-CERL using soil samples from around the U.S.
- All analysis will take place with and without Cathodic Protection
- Objective is to verify the use of flowable backfill to prevent long term corrosion in a simple, reliable, and cost effective manner

Questions

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